

The Design and Development of MusicBlox: A Musical Composition Toy Modeled for Children

McGill University, Electrical and Computer Engineering Dept.

Ahmad Zeid Al-Hammami

U4 Computer Engineering
zeido@sympatico.ca

Mayank Mehta

U2 Electrical Engineering
mayank.mehta@mail.mcgill.ca

Nicolas Gaumond

U3 Electrical Engineering
ngaumo@po-box.mcgill.ca

Anika Talapatra

U3 Electrical Engineering
anikatalapatra@yahoo.com

ABSTRACT

In this paper, we describe the design and development of MusicBlox, an interactive music creation toy. The toy is made for children ages 5 and up. It is designed to allow children to be creative through fun and experimentation without requiring any instrumental aptitude. Using two main components, MusicBlox maps musical staff composition to building blocks.

KEY WORDS

Affordance [3], conceptual model [3], design implementation, Human-Computer Interaction, iterative design [1], interactive systems, mapping [3], music, MusicBlox, toy, user-driven changes.

INTRODUCTION

A team of members from the Department of Electrical and Computer Engineering of McGill University created MusicBlox. Using MusicBlox, children can explore the process of music composition in a novel way: by physically attaching noteBlox together to create a musical line, and then having the toy playback their melody. Then, the child can revise his/her composition, learning the notes in relation to one another and harmonies between notes with each composition.

MusicBlox's expandable design offers unlimited possibilities in musical creation. The only requirements from the user are memorization and association of notes to colors, basic motor and listening skills, and basic comprehension of picture labels on function buttons. Creative capability and musical motivation are anticipated.

As the child progresses, a greater number of blocks can be used to form more complicated melodies. Also, two or more chains of blocks set to different instruments could be played simultaneously to form an orchestra.

The suggested term project theme was that of an interactive toy or game. It was also a part of the criteria that a conventional keyboard or graphics display screen not be used as the Human-Computer Interaction interface. The inspiration of MusicBlox appealed to all members of the group as an innovative idea that would be fun to design and implement, and it met the afore-mentioned conditions.

The project evolution came about through iterative design [1]. During each stage of the project, the team discussed and tested the current model with potential users, and then redesigned the toy based on empirical results. Iterative design allowed us to focus on users and tasks, and on making user-driven changes to the current model. This paper discusses the various stages our project went through before its final implementation. The evolution of the design and various user-driven changes are described in this paper.

STAGE 1 – INITIAL DESIGN

Our project went through many phases. Perhaps the most important stage was the one of envisioning what the user would gain from our product. Market research of similar products found a toy consisting of 5 blocks, and a base with five slots to place these blocks. Each block played various melodies, so the child could create millions of tunes. However, this is not a clear conceptual model of musical composition. In MusicBlox, each block represents a

separate musical note. This provides a direct mapping between the concept of composition using notes, to melody line creation using physical blocks. The fundamental elements in music composition are notes. Notes map to noteBlox, the fundamental building element in MusicBlox.

The initial design of MusicBlox consisted of 3 main block components: baseBlox, noteBlox, and the mainBlox:

BaseBlox are linked together to form a chain, representing the concept of a musical staff. Each baseBlox can have up to three noteBlox stacked on a baseBlox to form a chord. An empty baseBlox represents a musical silence.

NoteBlox are blocks of different color and size that represent different notes. Eight colors of blocks symbolize the eight notes that form a musical scale. Three available sizes of the noteBlox corresponded to three different note-values, a quarter note, a half note and a whole note. Also, each noteBlox has a note name on it, and picture of the note on a musical staff, so the user can learn the positioning and names of notes as he/she plays. Each noteBlox has a LED. As the notes are played, the noteBlox light up so the child can identify which are "out of tune".

The mainBlox is the central unit where the chain of noteBlox is read. The melody can be played out using one of three different instrument sounds, selected from the mainBlox. The instruments guitar, flute, and piano were chosen to represent the string, wind, and percussion classes of musical instruments, respectively. The user then uses the play/stop and volume button to play his/her composition. Ideally, features of the toy would include storage of a melody to playback later, and continuous looping. MainBlox can be disconnected and taken elsewhere without dragging blocks along so user can go show someone what he/she created without hassle.

The blocks are connected using side connectors and side receptacles. Each block, facing the user with the note name upright, has a side receptacle on its right hand face, and has a side connector on its left-hand face. The side connectors/receptacles are protrusions from the flat surface of the blocks, providing an affordance [3] that they are used for connection of the blocks to one another.

Evaluation Criteria

Our overall evaluation criteria were followed throughout the design and implementation of MusicBlox. The criteria are:

- Intuitive connection of noteBlox.
- No more than four instruction diagrams that are easy to follow, and task oriented.
- No more than five seconds to add each noteBlox, so that user can focus on the goal - the musical piece.
- Easy identification of 'wrong' notes, and easy change of notes within a string of noteBlox.
- The user should be able to naturally memorize the different tones of the noteBlox by the different colors of the noteBlox for each tonality.

STAGE 2 - EVALUATION PLAN

In order to test our initial design and have empirical feedback from potential users, we created an evaluation plan, to be used at each stage of the design. Results from the evaluation would lead to redesign of the toy, incorporating user-driven changes. Our plan consisted of three parts:

I - Evaluation Plan using Quantitative Measurement

Quantitative evaluation criteria to be measured:

1. Time to correct use
2. Number of mistakes before correct move is made

These measurements indicate how intuitive the system is:

1. Time to assemble first song
2. Time to play first song
3. Time to modify and play first song
4. Number of errors in assembling/playing

These measurements indicate the learnability of the system - how easy it is to use once one learned how to use it:

1. Time to assemble 2nd song
2. Time to play Second song
3. Time to modify and play 2nd Song
4. Number of errors assembling/playing the song

The following questions give the design team an idea of what is easily understandable about the system, and what isn't:

1. Time spent looking at the Usage illustration Diagrams before assembling/playing first song.
2. Number of Good comments: Things user liked.
3. Number of Bad Comments: Things user did not like.
4. Number of Questions posed by user: How many things are not intuitive.
5. Number of times user expresses frustration.

II - Cognitive Walkthrough

Steps to use MusicBlox are:

1. Linking in series of the noteBlox.
2. Linking of the mainBlox to one end of chain of noteBlox.
3. Selection of a musical instrument from the mainBlox.
4. Use of the mainBlox to start playing the musical composition.
5. Identification and correction of a 'wrong' note using the note lights.

The following identifies how the interface supports these steps:

The noteBlox have a note on them, and each musical note is represented by a separate color, so the user will understand that they are linked together to form a musical composition of notes. The noteBlox are linked using the side connections, clearly visible as connection points on the side of the noteBlox. The mainBlox has functions on it, so it can be identified as the mainBlox, and linked via side connections to the chain of noteBlox. The user selects an instrument from the instrument selection toggle button. The mainBlox has a button marked play music, which initiates play of the musical composition. There is a stop button to stop music play.

When the musical composition plays, each note lights as is plays. The user should thus be able to identify which note sounds 'out of tune'.

Minimal questions asked, maximum interest in the toy, and maximum positive responses from the user indicate that our initial evaluation criteria are satisfied.

III - Heuristic Evaluation

The Heuristic Criteria [2] used by our team were:

- Visibility of system status

MusicBlox informs the user about what is going on in the system. The user is informed about the state of

the system, either play or stop, through the position of the play or stop button. The user knows which instrument is selected through the position of the instrument toggle button. The user can identify which note is being played, and thus identify any notes he/she wishes to replace, through the lighting of each noteBlox during the play stage.

- User control and freedom

The user can stop the system by pressing the stop button. The user can undo or modify a musical composition by removing all or some of the noteBlox from the string. The user can change state of instrument selected easily, during or before play, by pressing on the instrument of choice on the instrument toggle button.

- Error prevention

The usage diagram that outlines the steps to use MusicBlox minimizes errors of operation.

- Aesthetic and minimalist design

MusicBlox can be used with little no learning time, as it is a simple system of noteBlox that are linked together to form a musical string, with one mainBlox to control play and instrument selection functions. The connection points on the noteBlox and mainBlox are large and easy to connect one block to another.

- Help users recognize, diagnose and recover from errors

Each noteBlox lights up as it plays. If a noteBlox is not lighting up, the user can remove this block from the system and replace it with another noteBlox.

These results of these three tests would be used to redesign the current model, to satisfy our overall evaluation criteria.

STAGE 2- PAPER PROTOTYPE AND SOFTWARE PROTOTYPE

Description

Our paper prototype and software prototypes are best described with pictures:



Figure 1: Paper Prototype

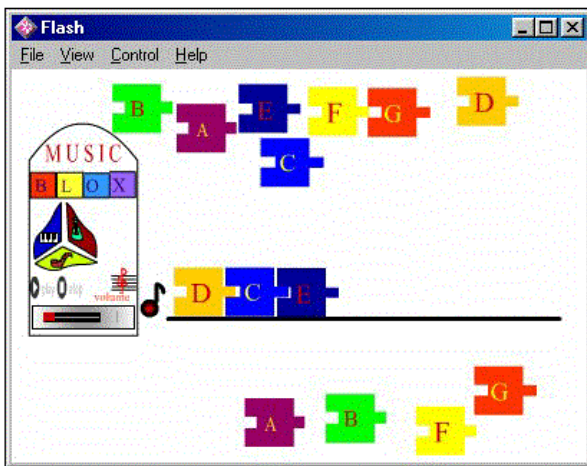


Figure 2: Software Prototype

Summary of User Evaluation

The results from users carrying out our evaluation plan were:

Positive feedback we received was that the system is very easy and fun to use, and the system was very easy to learn. The user found the design aesthetically sound. The noteBlox could be connected quickly and intuitively, using the instructions. The user was able, for the most part, to focus on the actual goal - musical piece creation. Notes were easily identified and changed at will.

First use of MusicBlox

The user assembled the first song in 1 minute, after reading on-line instructions. The user played a first song within 30 seconds. It took the user 1 minute to modify and play the first song. A few errors were made when the user did not realize the need to select an instrument before pressing play. However, the sequence of these steps is stated in the user manual. The user suggested the addition of a

pause button as a useful improvement, which will not be implemented to maintain simplicity.

Testing learnability of the system: The second use of MusicBlox

The user assembled the second song in 1 minute, and played it in 30 seconds. The user modified and played the second song in 1 minute. The user spent 5 minutes looking at the Steps to Use Diagrams before assembling/playing first song. The user loved the idea, the different colors for the different notes, the availability of different instruments, how easy it is to pick an instrument and the use of stop and play which became natural to use by the second use. The user expressed frustration 4 times, based on the results described in the next section.

Evolution of the Interface

Motivation

Having baseBlox makes the system complicated, adding an extra step before music composition.

Change

BaseBlox are removed from the system, allowing noteBlox to be directly connected.

Motivation

Stacking noteBlox to form chords, and having different note values increases the technical difficulty significantly.

Change

To make implementation feasible, only one note values will be represented, and the melody will consist of a single note string.

Motivation

The user did not like that there is no initial instrument selected.

Change

A solution would be to create a default instrument when MusicBlox is initially turned on. Also, so that the user is clear on the state of the system, the instrument selected will be indicated by the position of the toggle button.

Motivation

The user found that the system does not indicate when it is in play or stop mode.

Change

The play/stop will be combined into a single rocker button. The play position and stop position can be easily identified using a rocker button, such that the rocker is depressed either towards the PLAY or the

STOP level, for the entire duration of the play or stop modes, respectively. This satisfies the visibility of system status.

STAGE 3 – FIRST PROTOTYPE

Description

Drawing of our first prototype, including the mainBlox and one noteBlox.

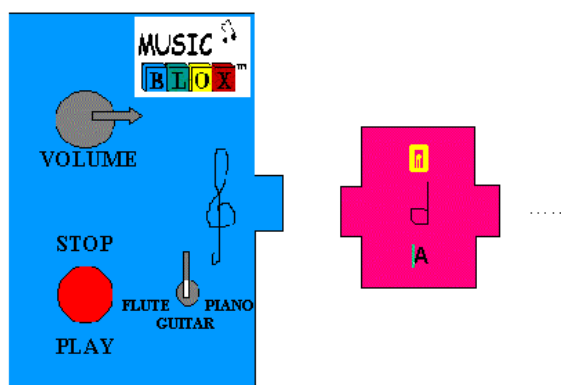


Figure 3: First Prototype

Summary of User Evaluation

The evaluating team found the overall experience pleasant. They enjoyed the clear visibility of the user interface and the proper labeling of the buttons.

Strengths of the Interface

The evaluation of our first prototype indicated that:

The name of the device is a very good hint at the functionality to be expected.

Physical affordances are quite clear overall.

The purpose and feedback of the STOP/PLAY button are very clear.

The musical lines starting from the mainBlox and at the top of each noteBlox give a good mapping of how to connect the blocks together.

The labels use language that is familiar to the user.

Evolution of the Interface

Motivation

Users found that the toggle switch was hard to use.

Change

We will leave more space around the toggle switch, and include simple, large drawings of the instruments, so that a child will be able to clearly select an instrument, and identify which one is selected.

Motivation

Users found that the user manual needed diagrams and more details.

Change

The user manual has many more diagrams and details on MusicBlox's use.

Motivation

Users suggested that the blocks should have internal, differently colored LED's. This would prevent a child from breaking an external LED.

Change

LED's were internalized and made a different color for each note.

Motivation

The foam board material used as casing is not strong enough to hold the side connectors.

Change

Wood will be used as casing material.

STAGE 4 - FINAL PROTOTYPE



Figure 4: Final Prototype

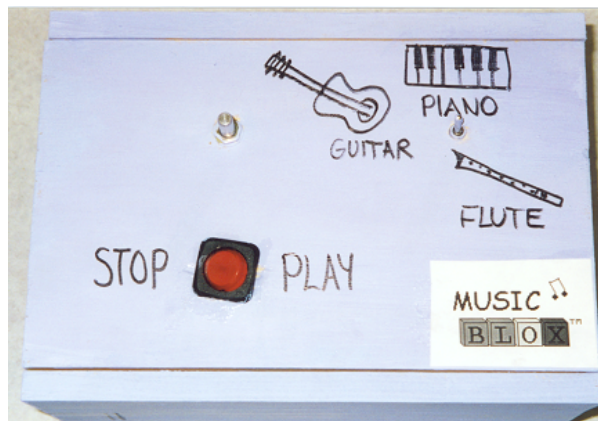


Figure 5: MainBlox of the Final Prototype

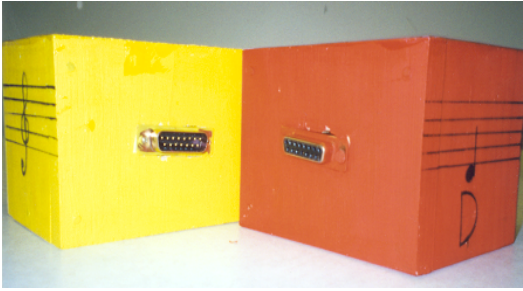


Figure 6: Side Connections of NoteBlox

Steps to Use MusicBlox

1. Link several of the noteBlox together in series, using the side connectors and receptacles (Figure 1).

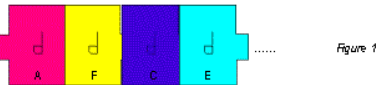


Figure 1

2. Link the mainBlox to the chain of noteBlox, by inserting the side connector of the mainBlox into the side receptacle of the noteBlox. The end of the noteBlox chain with the side connector should be free (Figure 2).

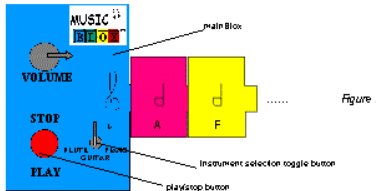


Figure 2

3. a. Select a musical instrument from the mainBlox, by moving the toggle to the chosen instrument (Figure 2).
3. b. Press the play button on the mainBlox to start playing the musical composition (Figure 2).

4. Identify which note is playing using the note lights. Change notes to create a new composition (Figure 3). Here, noteBlox 'C' is lit.

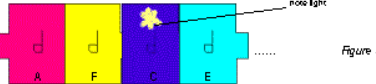


Figure 3

Figure 7: Instructions page from User manual.

In our final prototype, we had to implement a termination block, that has no note value, but must be connected to the end of the chain of noteBlox in order for the system to play. Ideally, a termination block would not be necessary in this toy, so it has not been included in the user manual.

Our Final Prototype has internalized LED's that light up when the note plays, allowing the user to identify which note is playing. Drawings of instruments for the instrument select button have been drawn clearly on the mainBlox (Figure 5), so the user can easily determine the state of instrument

selected. The play/stop button is a toggle switch, again so that information on system state can be clearly determined. The noteBlox are made of wood, providing solid blocks with affordances as connection points (Figure 6). NoteBlox are brightly colored, making the toy visually appealing, and making note tones easy to distinguish from one another (Figure 4). We wish the user entertainment and musical learning with our project.

ACKNOWLEDGEMENTS

We would like to thank Professor Cooperstock for his enthusiasm and expert knowledge in Human Computer Interaction. We thank the teams and evaluators who provided the indispensable empirical response to our prototypes throughout the evolution of our project.

Please note that details of the Design and Development of MusicBlox, and the complete User Manual can be found at <http://www.cim.mcgill.ca/~jer/courses/hci/assignments/2002/www.ece.mcgill.ca/%257Engaumo/hci/notebook/>.

REFERENCES

1. Gould, John D. et al. "The 1984 Olympic Message System: A Test of Behavioral Principles of System Design." *Communications of the ACM*. Volume 30, Number 9. September 1987.
2. Nielsen, Jakob. *Ten Usability Heuristics*. http://www.useit.com/papers/heuristic/heuristic_list.html. 1994.
3. Norman, Donald A. "The Psychopathology of Everyday Things." *The Psychology of Everyday Things*. Basic Books, 1988, pp. 1-29.